ORIGINAL ARTICLE

Reconcilable differences: correcting medication errors at hospital admission and discharge

T Vira, M Colquhoun, E Etchells

Qual Saf Health Care 2006;**15**:122–126. doi: 10.1136/qshc.2005.015347

See end of article for authors' affiliations

Correspondence to: T Vira, M D Candidate, Clinical Pharmacist, Markham Stouffville Hospital, Markham, ON, Canada L3R 7E8; tasnim.vira@utoronto.ca

Accepted for publication 24 January 2006

Background: Medication errors at the time of hospital admission and discharge are common and can lead to preventable adverse drug events. The objective of this study was to describe the potential impact of a medication reconciliation process to identify and rectify medication errors at the time of hospital admission and discharge.

Methods: Sixty randomly selected patients were prospectively enrolled at the time of admission to a Canadian community hospital. At admission, patients' medication orders were compared with pre-admission medication use based on medication vials and interviews with patients, caregivers, and/or outpatient healthcare providers. At discharge, pre-admission and in-patient medications were compared with discharge orders and written instructions. All variances were discussed with the prescribing physician and classified as intended or unintended; unintended variances were considered to be medication errors. An internist classified the clinical importance of each unintended variance.

Results: Overall, 60% (95% CI 48 to 72) of patients had at least one unintended variance and 18% (95% CI 9 to 28) had at least one clinically important unintended variance. None of the variances had been detected by usual clinical practice before reconciliation was conducted. Of the 20 clinically important variances, 75% (95% CI 56 to 94) were intercepted by medication reconciliation before patients were harmed.

Discussion: Unintended medication variances at the time of hospital admission and discharge are common and clinically important. The medication reconciliation process identified and addressed most of these unintended variances before harm occurred. In this small study, medication reconciliation was a useful method for identifying and rectifying medication errors at times of transition. Reconciliation warrants broader evaluation.

Adverse drug events and medication errors contribute to 20–72% of adverse events around the time of hospitalization[1–4] and 7–12% of all permanent disabilities and deaths due to adverse events.[5 6] Medication errors at the interfaces of care (admission, transfer and discharge) are particularly common,[1 2 7–13] and many of these errors put patients at risk of clinically important harm.[7–10]

''Medication reconciliation'' is a three step process of verifying medication use, identifying variances, and rectifying medication errors at interfaces of care.[14] Reconciliation is a process of double checking, including patient interviews as well as examination of available patient records, comparison with orders, and discussions with physicians. Some variances are intended therapeutic changes, but other variances are unintended and can be considered medication errors. If these errors have clinical consequences—that is, if they cause harm or have the potential to cause harm—then they can be considered actual or potential adverse drug events. Reconciliation is a 2005 Hospitals' National Patient Safety Goal established by the Joint Commission on Accreditation of Health Care Organizations (JCAHO).[15]

However, there have been few studies of the impact of reconciliation on medication errors during hand-offs in care. One study found that medication errors were reduced by more than 76% when medication reconciliation was implemented at admission, transfer, and discharge,[11 16] with the largest impact at admission. Another study in critical care found that errors at the time of discharge from a critical care unit were virtually eliminated by a reconciliation process.[17] A randomized trial found that post-discharge follow up phone calls by nurses reduced subsequent emergency department visits, but this study did not focus on medication errors or adverse events.[18] Another study found that adverse drug events were reduced when admission medication reconciliation was implemented together with other safety interventions.[19] A study of admission medication reconciliation found that 54% of patients had a discrepancy and researchers estimated that 59% would have resulted in harm had these variances not been discovered.[20] However, this study examined only admission reconciliation and did not involve physician assessment of potential harm.

Reconciliation is not without potential drawbacks. It is potentially labour intensive and time consuming for busy clinical pharmacists. Physicians may view the reconciliation process as irrelevant or superfluous, particularly if unimportant errors with little chance to improve the patient's outcomes are identified. We have undertaken a study of the frequency and potential severity of unintended medication variances at the time of hospital admission and discharge and the potential impact of a medication reconciliation process.

METHODS

This prospective study was conducted at Markham Stouffville Hospital, a 212 bed Canadian community hospital. Patients were randomly selected from all acute care units excluding the rehabilitation and chronic care wards on each weekday in July 2002. A random number table was used to select patients from all new admissions to the units in the previous 24 hours. There were no additional inclusion or exclusion criteria.

Abbreviations: ADE, adverse drug event; CPOE, computerized physician order entry

Table 1 Characteristics of study population (n = 60)

Mean (SD) age (years)	56 (24)
% women (n)	50% (30)
Mean (SD) no of prescription medications per patient at admission	3.6 (3.5)
Admitting service, % (n)	
Surgery	33% (20)
Medicine	33% (20)
ICU/CCU	14% (8)
Other	20% (12)
Unplanned admission, % (n)	78% (47)
Mean (SD) length of stay (days)	6.9 (6.8)

We allowed at least 24 hours after admission for usual clinical practice to occur before conducting medication reconciliation at admission. Usual clinical practice involved pharmacy or nursing verification of the patients' medication use history if requested by a physician or if there were incomplete or unusual drug orders. At discharge, pharmacists provided medication education if specifically requested by a physician and for additional patients as time permitted. The clinical pharmacist chose additional patients, if time permitted, from discharges involving patients with extended lengths of stay, multiple co-morbidities, and/or multiple medications or medication changes. Usual clinical practice was not interrupted as pharmacists and nurses were not aware of which patients were involved in the study. Usual pharmacy staffing at the hospital is two full time pharmacists covering the general medicine and intensive care/coronary care (ICU/CCU) wards.

A study pharmacist conducted the medication reconciliation process. A comprehensive medication use history was obtained from multiple sources (interviews with the patient and/or caregiver and examination of medication vials). Outpatient community pharmacies and/or doctors were contacted if necessary. The study pharmacist compared the comprehensive medication use history with the admission medication orders. Any difference between medication use at home and admission medication orders was considered to be an admission medication variance. A variance could include an omission of medication, extra medications, or discrepancies in dose, frequency, or dosage form. Variances in prescription medications and acetylsalicylic acid (ASA) were included in the study; variances in non-prescription medications, vitamins, and herbal supplements were excluded.

The study pharmacist discussed each variance with the attending physician immediately upon discovery to determine if the variance was intended or unintended. Unintended variances were considered to be medication errors. Appropriate medication changes were made at the physician's discretion. We recorded whether new medication orders were written to rectify the unintended variances and the study pharmacist's time required to conduct admission reconciliation. The cost of admission reconciliation was calculated by multiplying the number of hours spent by an hourly rate for clinical pharmacist time of $35 Canadian.

Patients were then followed to discharge or until the end of the study period (28 August 2002), whichever came first. The patients' discharge medications were determined from written discharge medication instructions and discharge prescriptions. This information was compared with the patients' preadmission medications and the medication administration records just before discharge. Any differences were considered to be discharge medication variances. The study pharmacist discussed each discharge variance with the attending physician to determine if the variance was intended or unintended. Appropriate medication changes were made at the physician's discretion. We did not record the time required for discharge reconciliation.

An internist reviewed each unintended variance to assess the potential and/or actual clinical importance. Unintended variances were classified as clinically important if they caused or had the potential to cause death, permanent or temporary disability, prolonged hospital stay, readmission, or the need for additional treatment or monitoring to protect the patient from harm.

The proportion of patients with at least one unintended medication variance was calculated, as well as the mean number of unintended medication variances per patient. Similar calculations were also made for clinically important unintended medication variances.

Ethics approval was obtained from the hospital's ethics committee and consent was obtained from all study participants.

RESULTS

Sixty patients were randomly chosen from 168 admissions during the study enrolment period. No patient refused to

Table 2 Summary of main findings for unintended variances

	Overall (N = 60)	Admission (N = 60)	Discharge (N = 56)
No of patients with at least one unintended variance (%, 95% CI)	36 (60%, 48 to 72)	23 (38%, 26 to 51)	23 (41%, 28 to 54)
Mean number of unintended variances per patient (95% CI)	2.3 (1.5 to 3)	1.2 (0.7 to 1.6)	1.2 (0.7 to 1.7)
Types of unintended variances (% of variances)			
Total number of unintended variances	136 (100%)	69 (100%)	67 (100%)
Omitted medication/prescription	80 (59%)	50 (72%)	30 (45%)
Incorrect/omitted details (dose, route, frequency)	18 (13%)	15 (22%)	3 (4%)
Additional medication unintentionally ordered	4 (3%)	4 (6%)	0
Lack of discharge instruction regarding medication changed in hospital	34 (25%)	NA	34 (51%)
No of patients with at least one clinically important unintended variance (%, 95% CI)	11 (18%, 9 to 28)	9 (15%, 6 to 24)	5 (9%, 2 to 16)
Clinically important unintended variances	20	10	10
Intercepted	15	8	7
Not intercepted	5	2	3
Variances leading to harm	4	2	2
Physician response to unintended variance			
Order new medication/prescription	21 (15%)	2 (3%)	19 (28%)
Discontinue or hold medication	3 (2%)	1 (1%)	2 (3%)
Change details (e.g. dose, route, frequency)	11 (8%)	7 (10%)	4 (6%)
Restart medication	31 (23%)	22 (32%)	9 (13%)
No changes made	70 (51%)	37 (54%)	33 (49%)
Total	136	69	67

Table 3 Description of clinically important unintended medication variances and the impact of the reconciliation

Case description	Timing of variance	Description of variance	Impact of reconciliation
(1) Patient admitted for myocardial infarction	Admission	Patient was taking metoprolol 25 mg bid at home. Patient ordered metoprolol 75 mg bid on admission. After first dose, patient was hypotensive and bradycardic	Patient experienced hypotension and bradycardia. Dose decreased after reconciliation.
(2) Patient with a history of CHF and angina admitted for hypertension	Admission	Patient was taking clonidine at home. Patient was ordered half of usual dose	Patient experienced severe hypertension. MD changed dose of clonidine after reconciliation and started additional antihypertensives
(3) Patient admitted for CHF and pneumonia	Admission	Patient was on metoprolol 12.5 mg bid at home. Metoprolol 50 mg bid ordered in hospital	Dose reduced
	Admission	Patient had discontinued using spironolactone before admission. Spironolactone 50 mg daily was ordered on admission: 3 doses given	Dose reduced
(4) Patient admitted for total hip replacement	Discharge	Patient was taking ketorolac at home. Ketorolac held while in hospital as patient was started on warfarin. Patient discharged on warfarin but not instructed at discharge to discontinue ketorolac	Patient informed to discontinue ketorolac
(5) Patient with history of CHF admitted for pneumonia	Admission	Furosemide used at home but not ordered at admission	Furosemide restarted
(6) Patient with metastatic cancer	Admission	Patient was taking hydromorphone as needed at home. Patient was started on morphine as needed (at half the equipotent narcotic dose). Patient's pain score was 7/10	Physician chose to continue morphine. Later changed to hydromorphone as patient continued to have pain
(7) Patient admitted for hepatic encephalopathy	Admission	Patient used fluticasone/salmeterol Diskus at home. fluticasone/salmeterol was not ordered	No new order
	Discharge	Spironolactone increased in hospital from 50 mg daily to 50 mg bid. No written instructions or prescriptions	Patient informed of increase in dosage
	Discharge	fluticasone/salmeterol held while in hospital. Patient not informed whether to restart fluticasone/salmeterol upon discharge	Patient informed to restart fluticasone/salmeterol
	Discharge	Estrogen held while in hospital. Patient not informed whether to restart estrogen upon discharge	Patient informed to restart estrogen
(8) Patient admitted for bowel obstruction. Ileostomy performed	Admission	Patient had discontinued hydrochlorothiazide at home. Ordered at admission but patient refused medication	Hydrochlorothiazide discontinued
	Discharge	Patient was on salbutamol before admission but was changed to Combivent in hospital. Patient not informed to discontinue salbutamol at home	Patient informed to discontinue salbutamol
(9) Patient with history of stroke admitted for COPD exacerbation	Discharge	ASA held while in hospital as patient was on ketorolac. Patient not informed to re-start ASA upon discharge	Patient informed before discharge
(10) Patient admitted for bowel surgery	Admission	Patient was taking lorazepam daily at bedtime at home. Medication was not ordered at admission	Doctor did not restart lorazepam
(11) Patient with diabetes admitted for hypoglycaemia, CHF and renal failure	Admission	Nifedipine XL used at home but omitted from medication history. Patient started on metoprolol in hospital	Physician chose to continue metoprolol and hold nifedipine XL
	Discharge	Furosemide was increased while in hospital, but discharge prescription was for pre-admission dose	Prescription changed
	Discharge	Insulin dose reduced significantly in hospital. Discharge prescription for insulin did not indicate dose. Patient resumed pre-admission dose	Missed opportunity to prevent harm. Patient readmitted with hypoglycaemia
	Discharge	Patient's metformin was discontinued in hospital. No instructions provided. Patient restarted metformin at home	Missed opportunity to prevent harm. Patient readmitted with hypoglycaemia
	Discharge	Nifedipine XL discontinued and metoprolol ordered in hospital. Metoprolol prescribed at discharge. Patient restarted nifedipine XL at home	Missed opportunity, no clear impact on patient

participate. Of the 60 patients enrolled, 56 were followed until discharge, two had not been discharged at the end of the study period, and two died in hospital; the latter four patients were excluded from discharge medication reconciliation analysis. Patient characteristics are summarized in table 1. Of the four patients excluded at discharge, one of those who died in hospital had a clinically important unintended variance at admission.

The main findings are summarized in table 2. Overall, 36 patients (60%, 95% CI 48 to 72)[21] had one or more unintended variances at admission or discharge, including 11 patients (18%, 95% CI 9 to 28) with clinically important unintended variances. The mean number of unintended variances was 2.3 per patient, and the median was 1 variance per patient, (interquartile range 0–4). The medication reconciliation process intercepted 20 (75%, 95% CI 56 to 94) clinically important variances before patient harm occurred. In two cases reconciliation identified a medication error as the cause of patient harm and mitigated further harm. In one patient three medication variances were identified but the intervention was not completed. The patient was readmitted with hypoglycemia partly related to two of the unresolved variances.

At admission, 23 patients (38%, 95% CI 26 to 51) had one or more unintended medication variances at admission, including 10 (17%, 95% CI 7 to 26) with three or more unintended variances. Of the 69 unintended variances at admission, 32 (46%, 95% CI 35 to 58) resulted in order changes by the physician upon intervention. The remaining 37 variances were not further addressed and no orders changed despite having been ordered unintentionally.

Overall, there were 10 clinically important admission medication variances affecting nine patients (15%, 95% CI 6 to 24). After reconciliation, six of these clinically important variances led to medication order changes. Complete case descriptions of clinically important variances are provided in table 3.

Two patients (patients 1 and 2 in table 3) experienced some harm because of the admission medication variances, but the reconciliation process brought the variances to light and probably helped to prevent further harm.

The median time required to conduct reconciliation at admission was 15 minutes (interquartile range 10–21). The mean cost per clinically important medication variance detected at admission was $64. This estimate was based on an overall time requirement of 1090 minutes for admission reconciliation for all 60 patients, yielding a total cost of $636 in pharmacist time.

At discharge, 23 patients (41%, 95% CI 28 to 54) had one or more unintended medication variances including 10 (18%, 95% CI 8 to 28) with three or more variances. Intervention was required after consultation with the physician for 34 of these unintended variances (51%, 95% CI 39 to 63). Overall, five patients (9%, 95% CI 2 to 16) experienced 10 clinically important discharge variances. Complete case descriptions for clinically important variances are given in table 3. The reconciliation process identified and intervened for seven of the clinically important variances. One patient had been discharged before the intervention for three variances was completed, and the patient was readmitted with hypoglycemia which would probably have been prevented had the intervention been completed (patient 11, table 3).

DISCUSSION

We found that 60% of patients (95% CI 48 to 72) experienced at least one unintended medication variance at admission or discharge, including 18% of patients (95% CI 9 to 28) who experienced 20 clinically important variances. Reconciliation intercepted 75% (95% CI 56 to 94) of these clinically important variances before harm occurred. The mean cost of admission reconciliation was $11 per patient or $64 per clinically important unintended admission medication variance, which compares favourably with the $2013–2595 incremental costs of adverse drug events.[22 23]

Our results are consistent with previous studies showing that medication errors at transitions in care are common.[1 2 7–13] The results add to previous descriptive studies of reconciliation that found reductions in medication errors by 70% or more.[11 17] Most importantly, we found that the reconciliation process detected and rectified many clinically important variances.

In our study physicians changed medication orders 49% of the time, whereas in studies involving pharmacists who accompany the physician team during rounds (the ''rounding pharmacist''), physicians accepted pharmacist recommendations 98% of the time.[24] Physicians may view some reconciliation changes as peripheral to the acute hospitalization (for example, Advair for a patient with hepatic encephalopathy) or unnecessary if an alternative course of action may be reasonable (for example, continuing morphine rather than changing back to hydromorphone). Also, reconciliation advice may have been less likely to be accepted because our reconciliation pharmacist was not an integrated member of the existing physician/pharmacist team.

Our study has several limitations. Firstly, we assumed that the best assessment of actual medication use before admission to hospital was a comprehensive interview by a pharmacist. This assumption is supported by a standardized patient study which found that pharmacists were 100% accurate for prescription and non-prescription drug use histories.[25] Secondly, clinical importance was judged by a single reviewer and others may not agree with the reviewer's judgements. We have included sufficient clinical detail about these cases to allow others to draw their own conclusions. Thirdly, we only studied prescription medication variances. Further studies are required in order to evaluate the frequency and clinical importance of variances in non-prescription and herbal medications. Finally, our study involved a small sample of patients from a single community hospital, so generalizability is limited. The rate of unintended variances in our study is similar to published studies from other settings, so we speculate that other hospitals would have similar experiences.

Box 1 Process recommendations for medication reconciliation programs

- Identification process for patients at risk:
  - Medication use history unclear (e.g. cognitive impairment or unclear patient history).
  - Complex medication use history (e.g. 5 or more medications).
- Admission reconciliation by pharmacist or nurse as soon as possible after admission to minimize potential harm during hospitalization.
- Pharmacist or nurse reconciles unintended variances by discussion with physician.
- At discharge, written instructions regarding pre-admission medications are included with discharge prescriptions.

Our results have several implications. Firstly, hospital patient safety programs should focus attention on medication errors at times of transition. Secondly, medication reconciliation was a useful method for identifying and rectifying medication errors at times of transition in this small study, and warrants broader evaluation. Medication errors and preventable adverse drug events are reduced when pharmacists accompany physicians on ward rounds;[24 26] introducing the reconciliation process to a pharmacist/physician team may offer additional benefits. Thirdly, computerized physician order entry (CPOE) systems have only a limited potential role in reconciliation at the time of hospital admission. An electronic outpatient pharmacy database which can be accessed in hospital allows detection of nearly all medication omissions at admission.[7 9] However, these systems only provide information about what has been prescribed. Only a detailed clinical interview can determine how patients are actually using their prescribed medications.

Once accurate admission medication information is obtained, a CPOE system could be very helpful in reducing errors at the time of discharge by generating automatic lists of medications used before and during the hospital admission, relevant drug monitoring data for the community physician, and patient education materials. This would facilitate the reconciliation process by making all relevant medication information available at the time of discharge.

After discharge, patients are often left to deal with medication variances without the support of hospital staff, so there may be greater potential for adverse drug events. We did not contact patients after discharge, but the potential value of this additional step warrants further exploration.[13 18] Process recommendations for medication reconciliation programs are shown in box 1.

In summary, unintended medication variances at the time of hospital admission and discharge are common and

significant. In this small study, medication reconciliation was a useful method for identifying and rectifying medication errors at times of transition. Medication reconciliation warrants broader evaluation.

ACKNOWLEDGEMENTS

The authors thank Dr Henry Solow, Chief, Department of Medicine and all the pharmacists at Markham Stouffville Hospital for their support while completing this study.

Authors' affiliations

T Vira, M D Candidate, Clinical Pharmacist, Markham Stouffville Hospital, Markham, Canada
M Colquhoun, Project Leader, Institute for Safe Medication Practices Canada, Former Director of Pharmacy, Markham Stonffville Hospital, Markham, Canada
E Etchells, Division of General Internal Medicine and Patient Safety Service, Sunnybrook & Women's College Health Sciences Centre and Associate Professor, Department of Medicine, University of Toronto, Toronto, Canada

This project was supported by an unrestricted research grant from Pharmaceutical Partners of Canada Inc.

Competing interests: none.

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